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Rethinking and reshaping the climate policy: Literature review and proposed guidelines

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ABSTRACT

Addressing climate change represents a governing the climate commons on a global scale. The "tragedy of the commons" might better be described as the "failure of governing the commons". Hardin's solutions were "centralized government" and "private property", which have long been criticized as oversimplified. However, governing the unprecedented climate commons, there is only a "global federalism of climate policy"—the Kyoto Protocol. The Kyoto cannot keep atmospheric CO_2 level below 450 ppm (rising 2 °C). Some key evidences of the Kyoto failures are identified. The Kyoto failures do not indicate that the Kyoto is a wrong tool of "centralized government". Instead, the Kyoto failures are derived from the fact that the only "centralized government" cannot effectively govern the commons, which have been proven by the efforts of governing the commons last four decades. Here we propose a wide diversity of governance systems for climate common to addressing global warming. The multi-level and multi-scale governing system includes but is not limited to: (i) starting at home, (ii) emphasizing the local approach, (iii) efforts of global-level focusing these top emitters, (iv) improved information sharing, (v) privatizing the property of climate to avoid "free riders", (vi) combination mitigation with adaptive, (vii) improved ecology services to expand carbon sinks. We argue that the Kyoto failures indicate again that reliance on a single "solution" may result in more of a problem than a solution in governing the common. Therefore, continuing to wait for another global federalism of climate policy may lead to missing the chance to make significant mitigations and adaptations in time to battling the climate change. Post-2012, multi-level and multi-scale approaches could make a difference in collective action for governing the climate commons to meet climate challenge.

Contents

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1. Introduction

“The tragedy of the commons” [1] has also beset the climate change [2–6]. Climate is shared by all, it is in each individual actor’s short-term interest to greenhouse gas (GHG) emission, rather than GHG reduction, so individual rational behavior driven by narrow short-term self-interest would lead to above 2 °C temperature rises (450 ppm CO_2e), and ultimately harm oneself [2–4].

The “tragedy of the commons” might better be described as the “failure of governing the commons” [6–8]. Hardin’s solution were two institutional arrangements – “centralized government” and “private property” [9,10] – which have long been criticized as oversimplified [6,8,10]. However, governing the climate commons – unprecedented complexity and uncertainly commons, there is only a “global federalism of climate policy”, i.e., the Kyoto Protocol – cutting GHG emissions through an international binding treaty under the United Nations Framework Convention on Climate Change [3,11]. Given that the Kyoto Protocol set to expire in 2012, countries have tried to set another globe federalism of climate policy – post-Kyoto pact – since 2008. However, the Climate Change Conference of 2009 Copenhagen, the 2010 Cancun and 2011 Durban have highlighted that a post-Kyoto binding agreement will not be reached before 2012.

To avoid the climate common become unprecedented “the tragedy of the common”, it is time to deeply rethink and radically reshape our climate policy for fighting global warming. To this end, the present article is intended to identify key failures of the Kyoto Protocol so as to break the illusion of waiting for a “panacea” to emerge from global federalism of climate policy, and propose multi-scale and multi-level approaches to govern the climate commons and to avoid the tragedy of the climate commons.

2. Two key evidences of the Kyoto failures

2.1. *The Kyoto system incompetence to lower carbon emission*

The Kyoto Protocol can neither effectively curb GHG emission, nor keep atmospheric GHG level below 450 ppm CO_2e [12–17]. Global GHG emission continued to track the most carbon-intensive scenario of IPCC [12–14] (see Fig. 1). Even worse, growth rate of global fossil-fuel CO_2 emissions has increased from 1.0% yr^{-1} for 1990–1999 to 3.4% yr^{-1} for 2000–2008 [12,13,15]. Global carbon dioxide emissions from fossil-fuel combustion and cement production grew 5.9% in 2010, surpassed 9 Pg of carbon (Pg C) for the first time [16]. Since 1960s, only major economic crises have led to important changes in the trajectory of global CO_2 from fossil fuel combustion and cement production. As shown in Fig. 2, only economic recession has lowered the global fossil fuel and industrial CO_2 emission in the long term.

2.2. *Annex-B countries outsourcing their carbon emission*

Article 3 of the United Nations Framework Convention on Climate Change (UNFCCC) states that “the Parties should protect the climate system… on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities” [19]. Under the principle of “common but differentiated responsibilities”, the heart of the Kyoto Protocol lies in setting stringent target for Annex-B countries (37 developed countries excluding the United States) for reducing GHG emissions, whereas non-Annex B countries (developing countries) are not subjected to emission reduction commitments [20–24]. However, economic performance and job creation, rather than GHG in atmosphere remain main criterion for choosing government leaders in the most developed countries (Annex-B). We have to confess that there is still lacking of sustainable and substantial force to drive national government – the signer and endorser of the Kyoto – cutting GHG emission. If the Annex-B countries appear lowering GHG emission, this is partly because they have exported the GHG emission to non-Annex B countries.

The Kyoto protocol has defined the accounting framework for GHG emissions on production-based inventory, rather than consumer-based inventory. The producer-based inventory includes all carbon emissions from the production within a country wherever these are consumed, and does not take into account emissions generated in import goods. Compared to this, the consumer-based inventory is refereed as the emissions from

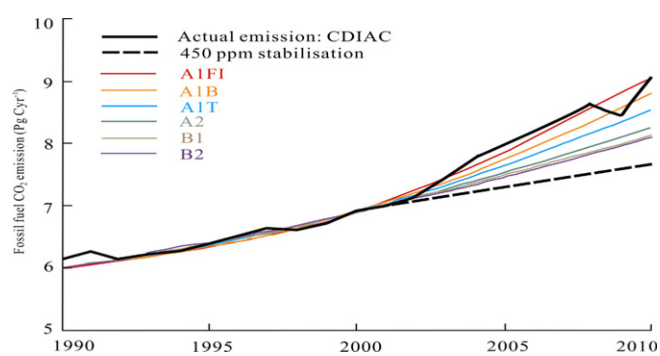

Fig. 1. actual global CO_2 emissions, compared with emissions scenarios and stabilisation trajectories.
Source: [12,16–18].

Fig. 2. The change in the trajectory of global fossil fuel and industrial CO_2 emission responds to the economic recession .
Source: [16].

Table 1
The difference between producer-based accounting and consumer-based accounting of Annex B and non-Annex B countries.
Source: [25].

	Component	1990 (Gt CO_2)	2008 (Gt CO_2)	Growth (%/y)
Annex B				
Domestic	Annex B Domestic (Bdom)	11.3	10.8	−0.3
Trade component	Annex B to Annex B (B2B)	2.1	2.2	0.2
	Annex B to non-Annex B (B2nB)	0.7	0.9	1.8
Production	Annex B production (Bprod = Bdom + B2B + B2nB)	14.2	13.9	−0.1
Consumption	Annex B consumption (Bcons = Bdom + B2B + nB2B)	14.5	15.5	0.3
Non-Annex B				
Domestic	Non-Annex B domestic (nBdom)	6.2	11.7	4.6
Trade component	Non-Annex B to Annex B (nB2B)	1.1	2.6	7.0
	Non-Annex B to non-Annex B (nB2nB)	0.4	2.2	21.5
Production	Non-Annex B production (nBprod = nBdom + nB2B + nB2nB)	7.7	16.4	5.9
Consumption	Non-Annex B consumption (nBcons = nBdom + B2nB + nB2nB)	7.4	14.8	5.3
Trade totals	Traded emissions (B2B + B2nB + nB2B + nB2nB)	4.3	7.8	4.3
	Trade balance (B2nB − nB2B)	−0.4	−1.6	16.9
	Global emissions (Bprod + nBprod = Bcons + nBcon)	21.9	30.3	2.0

Annex B components: Bdom, emission to produce and consume goods and services in Annex B countries; B2B, production in one Annex B country with consumption in another Annex B country; B2nB, production in an Annex B country with consumption in a non-Annex B country. Likewise for non-Annex B countries (nBdom, nB2B, nB2nB).

goods and services consumed by residents in a country, wherever they come from. The data of producer-based inventory show GHG emissions in Annex-B countries fell around 2% from 1990 to 2008 [12,15]. But once carbon imports from non-Annex B countries are added, Annex-B countries' GHG emission actually went up by nearly 5.7% from 1990 to 2008 [25]. Annex-B countries have committed themselves to an average carbon reduction of 5% in 1990 levels by the year 2012 [26], which represented that the average carbon reduction was about 0.7 Gt CO_2 yr^{-1}. However, the net average annual emission transfer via international trade from non-Annex B to Annex B countries between 1990 to 2008 is 18% higher the reduction target of 0.7 Gt CO_2 yr^{-1} [25] (see Table 1).

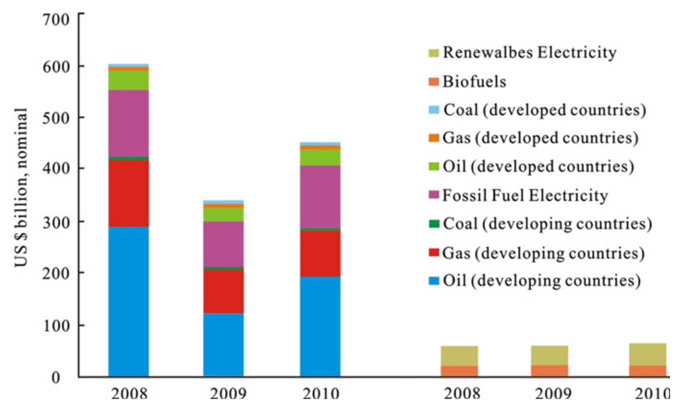

Fig. 3. Estimated global energy consumption subsidies for fossil fuel and renewables during 2008–2010. .
Source: [33].

2.3. The carbon market (flexible mechanism) fault

In July 2001, the Kyoto Protocol was revised in Bonn (the Kyoto–Bonn Accord). Trading emission allowances was added as "flexible mechanism" of meeting the binding carbon reduction target in the Kyoto–Bonn Accord. The Kyoto tried to get countries to set carbon emission caps, which were to be translated into permits, and then traded. Compared to the all-genuine markets evolved from the bottom up approach, the Kyoto carbon market was built by the top down approach [27]. The Kyoto carbon market has been criticized as a trading platform to simply buy more permits to emit more GHG [21–24,28–32]. For example, low carbon energy industry remains vastly under supported. Recent projection places the total value of conventional global fossil fuel subsidies between $775 billion and more than $1 trillion in 2012, depending on which supports are included in the calculation. In contrast, total subsidies for renewable energy stood at $66 billion in 2010, although that was a 10% increase from the previous year. Two thirds of these subsidies went to renewable electricity resources and the remaining third to biofuels (see Fig. 3) [33].

2.3.1. The fault of the European Union-Emissions Trading Scheme (EU-ETS)

Although the first phase of European Union-Emission Trading Scheme (EU-ETS) was created to operate apart from the Kyoto Protocol, the EU later agreed to incorporate Kyoto Protocol flexible mechanism certificates as compliance tools within the EU-ETS [34]. So far, autumn 2012, the EU-ETS is the world's largest emission trading program. It includes 11,000–12,000 power stations and industrial plants that produce half of Europe's total carbon emissions [35]. The EU-ETS was designed to encourage companies to invest in technologies that reduce their emissions in the long term [36]. After two development stages of the EU-ETS since 2005, however, it has been criticized for encouraging the companies to buy allowances and emit the same rather than investing in low-carbon efficiency and green technologies [28,37–43]. The faults of the EU-ETS include but are not limited to:

(i) Carbon pricing mechanism failure
Compared to the all genuine commodity prices evolved from the bottom up approach, the carbon price is set by the top down approach. An emission cap for individual industrial sector was set by the European Commission. Companies were approved to set their own baselines of carbon emission and determine their own abatement cost curves. These data were submitted to national government. Based on these data, national government submitted a National Allocation Plan to the European Commission [44]. The top down approach has deeply distorted the workings of the free market mechanism and can eventually lead EU-ETS to deliver the unstable and

low carbon price [28,40–42,45]. For example, a stream of new projects was approved by the European Commission in 2005, the market traders anticipated carbon credits over-allocation and market glut. As a result, carbon price dropped from around €20 per ton in 2005 to less than €10 in April 2006. Later in 2006, again, prices reached a peak of €30 per ton, but after governments added emissions allowances the price plummeted to €10 per ton in September 2007 [28,45]. This unstable and low carbon price has discouraged the companies to invest low carbon technology [40–42]. For example, a survey of EU-ETS effectiveness found that 85% of some regulated industries in different sectors had trouble deciding whether to purchase credits or begin abating their emissions [43].

(ii) Free allocation and windfall profits
Many loopholes have enabled profiteers to make money from the top-down creation of carbon market, without materially affecting emissions [21,46,47]. Most notably, the EU allowances (EUAs) was mainly freely allocated to firms, whereas the price of EUAs was passed fully in the final price of electricity, which resulted in a massive windfall gain to electricity companies. Even worse, the firms used revenues from the EU-ETS to reinvest in fossil fuels and activities that emit greenhouse gases [28]. For example, the EU large power utilities passed on the opportunity costs of withholding carbon credits to raise their value in the EU-ETS directly to consumers and ratepayers, producing windfall profits of about $112 billion that were then funneled back into fossil fuel fired power plant [28,48].

The failure of EU-ETU has discouraged other countries to conduct carbon trading trials. In generally, the global carbon trading trials seem to be halted. The carbon trading came unstuck in US which has set a global example of cutting SO_2 emission through cap-and-trade system [49]. The U.S. nationwide carbon cap-and-trade market has signaled the death of the seven-year-old industry in November 2010 [50]. In 2011, the Obama Adminstration failed to get its cap-and-trade plan passed in Congress [51].

2.3.2. *The fault of clean development mechanism*

As mentioned earlier, the Kyoto Protocol sets binding targets for developed countries' GHG emissions, whereas developing countries are implementing non-binding reduction initiatives. To encourage developing nations in controlling carbon emissions, the Kyoto Protocol established the CDM [52,53]. The CDM works by paying developing countries to adopt advanced low-carbon technologies than they otherwise would [28,53].

On major flaw of CDM is the risk of fraud. Compared to business as usual, "additional" is prerequisite for a CDM project. However, the fact was sometimes covered that the carbon reduction acquired through the CDM-project are not "additional". For example, some hydropower recognized as a CDM-project were already completed at the time of registration and almost all were already under construction, which means that Certified Emission Reduction (CERs) issued for projects that are not additional [54–58].

Another flaw is high transaction costs. Transaction costs of CMD are higher for offsets than for normal trading, since offsets must involve a baseline, monitoring, allocation, and compliance oversight on a trade. A 2007 survey found that more than 60% of respondents identified transaction costs such as time for approval and registration with the CDM Executive Committee as major barriers towards investing global carbon markets [59].

3. Multi-scale and multi-level system to govern the climate commons

However, those failures as mentioned above do not indicate that the Kyoto is a wrong tool of the nature as an instrument of "centralized government". The "centralized government" approaches – binding environmental treaties – have been approved to effectively deal with ozone depletion and SO_2 emission [60]. Ozone depletion has be prevented by controlling a small suite of artificial gases, and SO_2 emission has been decreased mainly by controlling emission from power generation [21]. In contrast, climate change is more complexity and uncertain problems than ever before. The well-documented close relationship between economic growth and fossil energy use and attendant carbon emission [12–14,61,62] indicates the GHG emission is an almost inherent result of economic development. For example, the contributions factors to the increase in CO_2 growth rate was $65 \pm 16\%$ from increasing global economic activity between 2000 to 2006 [13], whereas the global financial and economic crisis in 2008 drive the global CO_2 emissions from fossil fuel burning decreased by 1.3% in 2009—the first time since 2000 [18]. Therefore, governing the climate commons must be involved in revolutionizing the economic and social development model driven fossil fuel energy since industrial revolution [63]. We contend that the Kyoto failure is derived from the fact that neither "centralized government" nor "private property" can effectively govern the complexity commons [6,8,64,65].

Four decades of governing the commons repeatedly show that only a wide diversity of adaptive governance systems can effective stewards of common resources, whereas reliance on a single "solution" is naïve and may result in more of a problem than a solution in some cases [6,8,66–68]. Given the complexity of climate common, it is unreasonable that waiting for another "global federalism of climate policy" emerging from global negotiation. Instead, polycentric system should be considered and taken [2–5,69]. In addition to a global binding treaty post-Kyoto, we believe that institutional diversity should possess at least seven central elements of governing the climate commons (see Fig. 4).

3.1. *Multi-scale approaches*

Major climate policies and mechanisms exist at a global scale, because the Kyoto demonstrates a global approach to governance carbon [22–24]. However, given climate change is a complexity governance problem, it is not just a matter of policies and mechanisms at a global scale. In addition, if not backed up by a variety of efforts at national, regional, and local scale, policies and measures at a global scale might not guaranteed to work well. Instead of focusing on global-scale policies, multi-scale approaches are recommended.

3.1.1. *Starts at home*

In the authors' view, more actions should take place in households. Although the effects of protect the climate common are complexity and variety, the bottom line cause of GHG emission is household consumption [70]. On the global level, 72% of GHG emissions are related to household consumption, whereas 10% to government consumption, and 18% to investments [71]. In addition, given the population in this planet is 7 billion, there is no way to curb GHG emission, if our consumption is not transition toward to low carbon model [70]. Indeed, actions taken at a family level can make a substantial difference. For example, in US, if a family changes its fundamental behavior relating to home insulation, carpooling, and the purchase of

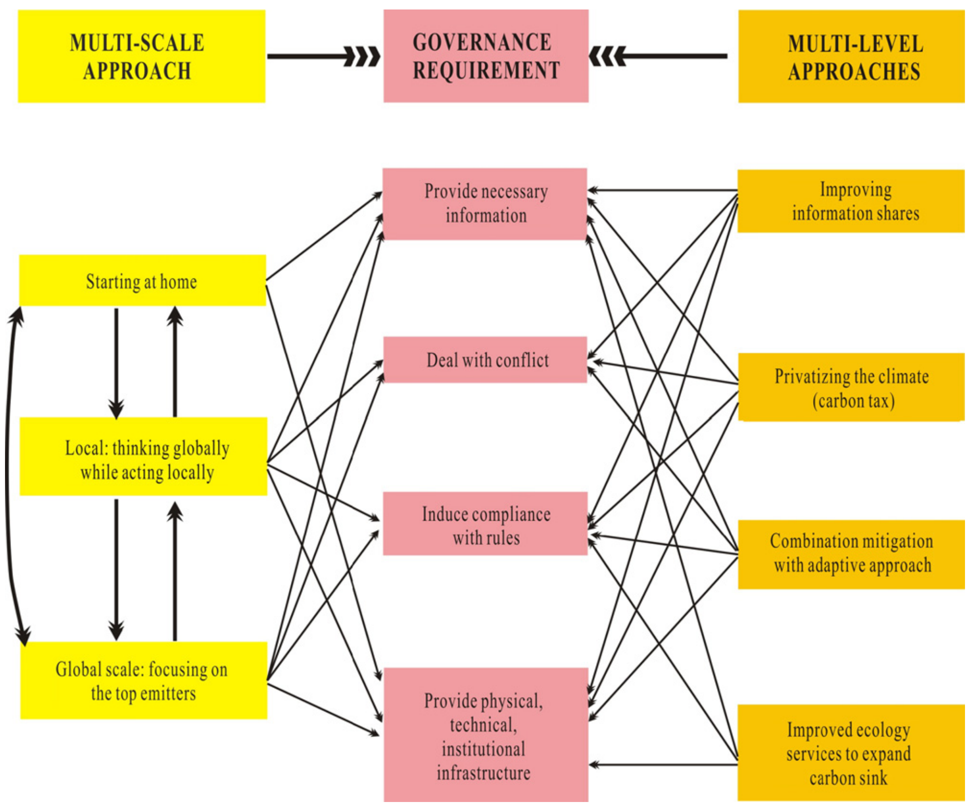

Fig. 4. Multi-scale and multi-level governance of climate commons. (governance requirement [center column] Ref. [6]).

fuel-efficient cars, these actions would cumulatively reduce their energy use and GHG emission by around 30% in US [5,72].

The limited success of energy-efficiency campaigns during the energy crisis of the 1970s, and the failure of campaigns that encouraged mass transit and carpooling over the last several decades, show behavior change is a gigantic challenge [72]. Single policy tool is in no way to drive household and individual behavior change [72–75]. For example, traditional economic models of rational choice through price signal cannot effective drive household and individual behavior change. Instead, financial incentives alone typically fall far short of producing cost minimizing behavior—"energy efficiency gap" [74,76].

Behavior change is more complex, requiring the successful integration of variable dynamics [74]. This demands to develop and deploy low-carbon technology. It also requires an adaptive carbon tax, which internalizes the cost of carbon emission into the cost of the products and services, theoretically meaning that the consumer will decrease the carbon content of their consumption for their self-interests. But above all, behavior change must be involved in a fundamental extension in morality [1,9], which might be deeper influence than technology and economics.

The wealth countries should take more responsibilities for behavior change. For example, switching from SUVs to fuel-efficient passenger cars in U.S. alone would nearly offset the emissions generated in providing electricity to 1.6 billion poor people in developing countries emission [77].

3.1.2. Local scale—"Thinking globally while acting locally"

Local scale approaches have been largely neglected after established Kyoto system, whereas global-scale solution has been the only game in the town [21–23]. However, local scale measures and policies might be more effective than the global scale. Extensive research on "collective action" show that many groups in the field have self-organized to develop solutions to common-pool resource problems at a small to medium scale, contrary to the conventional theory of "the tragedy of the commons" [5,6,8,78]. Moreover, local scale efforts are more urgent. Almost all impacts and inter-annual variability of climate change occur at a regional and local scale, although climate change is a global issue and long-term trend [79].

Local scale policies and measures should viewed not only as a part of efforts to effectively govern the climate commons, but also as a global scale policy experiments from which lessons could be learned about what works, when and where. For example, the US system of federalism encourages small-scale policy experiments at the state or local-government levels as well as with the philanthropic and private sectors. When state or local policies succeed, such experiments can be implemented at the national-scale [80].

Civil society should take a leading role in local scale measures and policies [81]. Local collective action to govern the climate commons represents not a single event, but is a systemic process. Local-scale polices and measures range from self-education, informational instruments, to toward low-carbon consumption. In such processes, Non-Government Organization (NGOs) has played an irreplaceable role [81,82]. NOGs provides a forum where different interest individuals can launch public debates related to climate-change issues and arouse the attention of the general locals. Public momentum spurs the formulation of new decision-making and modus operandi. The locals and NOGs also ensure that these policies will be upheld by monitoring the government. Indeed, almost in each conference of UNFCCC since 1995, the numbers of participants from NGOs is usually higher than the number of participants from government [83]. NGOs is "thinking globally while acting locally", and integrating actions into their special domestic political or cultural environments [84]. NOGs therefore might facilitate climate protection at local scale in

which locals are protecting their climate commons by voluntary collective action without any political purpose or commercial interests.

3.1.3. Global scale—Focusing on the top emitters

The Kyoto supporters hold that engaging all of the global government is matching global threat with universal response. However, the more parties there are to any negotiation, the lower the common denominator for agreement [21,24]. This can be shown the climate summit at Copenhagen in 2009, at Cunkun in 2010, and at Durban in 2011. Given that a new legally binding global carbon emission reduction agreement will not be reached before 2012 when Kyoto's first leg ends, it is unreasonable that a global scale solution is just relying on such everyone-in approach. Instead, a variety of policies should be considered and taken.

One of collective actions at global-scale should come from the top 20 GHG emitters, which are responsible for about 80% of the world's emissions [15]. In this sense, action to curb or expand carbon emission in those top 20 emitters determine whether governing global climate commons succeed or fail. If these top 20 nations act to curb emissions, the rest of the world can more easily coalesce on carbon reduction. If they fail to act, the mitigation strategies adopted by the rest of the world will fall far short of averting disaster for large parts of the earth. G20 summit provides forum of dialogue to governing the climate commons. The climate change dialogue should become one of the core issues of annual G20 summit.

Another critical collective action at global-scale must be come from China and U.S., Together, China and U.S. produce over 40% of global GHG emissions [15]. Without the world's two largest carbon emitters forging an unparalleled and extensive collective exercise, governing the climate commons will remain intractable and unsolvable [85–87]. Chinese and American political leaders appear to recognize the necessary of such corporation, released a series of ambitious programs of cooperation, and established multi-level bilateral cooperation mechanism since 2004. However, Sino-U.S. climate cooperation mainly takes place on paper and appears in slogans [88].

3.2. Multi-level approaches

The Kyoto's architects assumed that climate change would be best attacked directly through global emissions control, GHG to be reduced via mutually verifiable targets and timetables. Indeed, the existing efforts derived from the Kyoto have exclusively focused on the mitigation, which is dominated by command and control approach [21–24]. However, given climate change is not a discrete problem, it is not an amenable to a directive mitigation solution [5,69]. Moreover, if not backed up by a variety of efforts from information sharing, privatizing the commons, adaptive, and carbon sink, policies and measures of mitigation might not guaranteed to work well. Instead of focusing on mitigation policies, multi-level approaches are proposed.

3.2.1. Improving information sharing to cultivate collective action

Extensive research show that good information sharing is an essential for established trust and reciprocity among individual actor involved, which is closely associated with successful levels of collective action [5,6,8]. However, climate information sharing does not work well. Although a majority of individuals have expressed concern about climate change for many years [89–91], skepticism regarding global warming seriousness and anthropogenic causes has increased recently, partly because of "Climategate" [89,90]. In addition, public perceptions typically reflect a much lower concern about climate change than is expressed by climate scientists [92].

Effective sharing climate information demands continuous climate information at multi scale. At the global scale, climate information means not only factual information about the human-climate system, but also information about uncertainty. Although extensive researches show the anthropogenic causes of global warming is no doubt, scientific understanding of human-climate system remains some uncertainties, because of the inherent complexity in the human-climate system. "Climategate" shows how a paradoxical mixture of religious metaphors and demands for "better science" allowed those disagreeing with the theory of anthropogenic climate change to undermine the authority of science and call for political inaction with regard to climate change [89]. Individual actor needs information that characterized the types and magnitudes of this uncertainty, which must not undermine but strengthen the fact of anthropogenic global warming.

At the local scale, it should emphasize actor's first-hand experience of potential consequences of climate change. Individual who has direct experience of phenomena that may be linked to climate change would be more likely to be concerned by the issue and thus more inclined to undertake protecting climate commons. In the UK, for example, those who report experience of flooding express more concern over climate change, see it as less uncertain and feel more confident that their actions will have an effect on climate change. Importantly, these perceptual differences also translate into a greater willingness to save energy to mitigate climate change [91].

3.2.2. Privatizing the climate to avoid "free rider"

A perennial problem in collective action is how to avoid "free riders" who consume a resource without paying for it. When participants fear they are being "suckers" for taking costly actions while others enjoy a free ride, more substantial effort is devoted to finding deceptive ways of appearing to reduce emissions while not actually doing so [5]. To avoid free rider, emission permit is necessary in the global and national scale, whereas carbon tax is an indispensable tool in the global and local scale [93]. By levying on the carbon content of product and service goods, carbon tax seeks to shift the responsibility for carbon emission from the indefinite common to the entities consuming it.

Theoretically, a harmonization carbon tax – all nations would be subjected to a tax at a common rate – is necessary, provided that the world income distribution was equitable [94]. However, in an inequitable world, having developing countries being subject to the same tax rates as developed countries is unjust and unpractical. A harmonization (border carbon tax)—differentiated (domestic carbon tax) carbon tax is more rational and practical. The initial carbon tax should set a relative low, which is based on the welfare of the emerging countries. Such border carbon tax is necessary, but not sufficient, for an equitable carbon tax system. The differentiated domestic carbon tax should be introduced, which is set high enough to make low-carbon product more preferentially for individual's self-economic interest.

Three measures tools, i.e., process, input–output and hybrid life cycle assessment, are used to calculate carbon footprint of products [95]. Based on the three standards, there are a dozen of models. Both approaches and models are heavily depended on the definition of boundaries and data of production chain, which complicates the calculation carbon footprint of same product [96]. The more complex the product, and the more countries involved in the value chain, the more difficult it is to calculate carbon footprint. In some cases, some approximations are inevitable. Generally, the calculation of the carbon footprint of fossil fuel and

energy-intensive products is relative precise, the carbon tax therefore could focus on these fossil fuel (coal, oil, and gas) and carbon-intensive products (cement, steel, and chemicals) first.

3.2.3. Combination climate mitigation with adaptive approach

The existing efforts derived from the Kyoto exclusively focus on mitigation. In contrast, adaptation was misunderstood as a cost of human-caused climate change that would be avoided if climate change were prevented through emissions mitigation for a long time [21,23,24]. Moreover, the policy community suppressed discussion of adaption out of fear that it would blunt the arguments for mitigation efforts [21]. However, no matter which mitigation efforts we take, the climate will be changing over the next few decades—not only because of the GHG that are already out there, but also because of natural climate variability [21,79,97]. Virtually every climate impact projected to result from increasing GHG concentrations – from rising storm damage to declining biodiversity – already exists as a major concern. On longer timescales, the amount of mitigation achieved will dictate the magnitude of adaptation that is still required [79]. Therefore, adaptation should be an essential part of climate policy alongside mitigation.

Today, although the important of adaptive has been recognized [63], more efforts remain need: (i) Policy-makers should understand the limitations of mitigation for reducing vulnerabilities, and give more urgent consideration to broader adaptation policies – such as improved management of coastal zones and water resources – that will enhance societal resilience to future climate impacts [97]. (ii) More surveillance and early warning information is urgent. (iii) The budged of adaptive should be increased remarkably to improve capacity building of adaptive. The commitment of international resources to the multilateral Adaptation Fund under the United Nations Climate Change Convention is less than one-tenth of funds for mitigation [21]. (iv) It is urgent to provide the most vulnerable countries with climate services to help them adaptive. For example, to weather these changes, Bangladesh will need a gargantuan effort bolstering its infrastructure [98].

3.2.4. Improved ecology services to expand carbon sink

One of the most important strategies to keep atmospheric GHG level below 450 ppm CO_2e is enhancing carbon sink of terrestrial ecosystem [99,100]. Carbon uptake by terrestrial ecosystem contributed to about 30% of anthropogenic carbon emission from fossil fuel and land-use change. Forests are major contributors to this terrestrial carbon sink [100]. Unfortunately, expanding pasture and farmland has led to much recent deforestation, especially in South American and Southeast Asia. For example, tropical deforestation in Brazil reach to an average of 19,500 km^2/year from 1996 to 2005, which released 0.7 to 1.4 Gt CO_2e per year to the atmosphere [101]. The UN initiative on Reducing Emissions from Deforestation and Forest Degradation (REDD) offers financial incentives to developing countries to reduce deforestation, which has been further emphasized at Cancun 2010 climate summit [102]. In the future, the REDD should be upgraded to as ecosystem service.

Terrestrial sinks are part of an active ecological cycle. About 50% of the initial uptake of carbon through photosynthesis is used by plants for growth and maintenance. The remaining carbon is net primary production. Part of this is shed as litter and enters the soil, where it decomposes, and releasing nutrients to the soil and CO_2 to the atmosphere. The remaining carbon after these emissions is net ecosystem production. Much of this is lost by nonrespiratory processes such as fire, insect damage, and harvest. The remaining carbon is called net biome production (NBP). NBP is a small fraction of the initial uptake of CO_2 from the atmosphere and can be positive or negative; at equilibrium it would be zero. NBP is the critical parameter to consider for long-term (decadal) carbon storage [99]. A full ecosystem service applied to all terrestrial ecosystem would account for all potential terrestrial sinks and sources, not just those of the REDD forest, and would help identify other sinks that could be increased through management.

An ecosystem service requires understanding the nature of terrestrial carbon sinks—their distribution, control, longevity, and reliability. Recent breakthroughs in using geographic information systems and in-depth knowledge of the biophysical settings to map ecological systems over time are beginning to provide the tools needed for more careful planning for improvements in ecological systems. The models, however, need to be developed at multiple scales and decision-making units so that they can then determine which policies can be adopted to improve carbon sequestration in line with the ecology at that particular scale [5,103].

4. Conclusion

Meeting the potential unprecedented tragedy of the climate commons, we share in common. Collective action is not optional but imperative, as no one country can win the battle against climate change acting alone. Given such collective action is involved 7 billion people, there are no "optimal" solutions for such collective action. Four decades of governing the commons repeatedly show that reliance on a single "solution" is naïve and may result in more of a problem than a solution. However, governing the unprecedented climate commons, there is only a "centralized government"—the Kyoto Protocol. Indeed, with the Kyoto Protocol, this planet has continued to see an unprecedented increase in the accumulation of carbon dioxide in the atmosphere. We argue that the Kyoto Protocol is failure, although the Kyoto is not a wrong tool of the nature as a tool of "centralized government". The Kyoto failures are derived from the fact that only a wide diversity of adaptive governance systems can effective stewards of common resources. We therefore emphasize that continuing to wait for another global binding treaty may lead to missing the chance to make significant mitigations and adaptations in time to battling the climate change. Post-2012, Multi-level and multi-scale approaches could make a difference in collective action for governing the climate commons to fighting the global warming.

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